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Biological Evaluation of the

Eastern Hemlock Trees at the Old House Run Picnic Area

Monongahela National Forest, West Virginia

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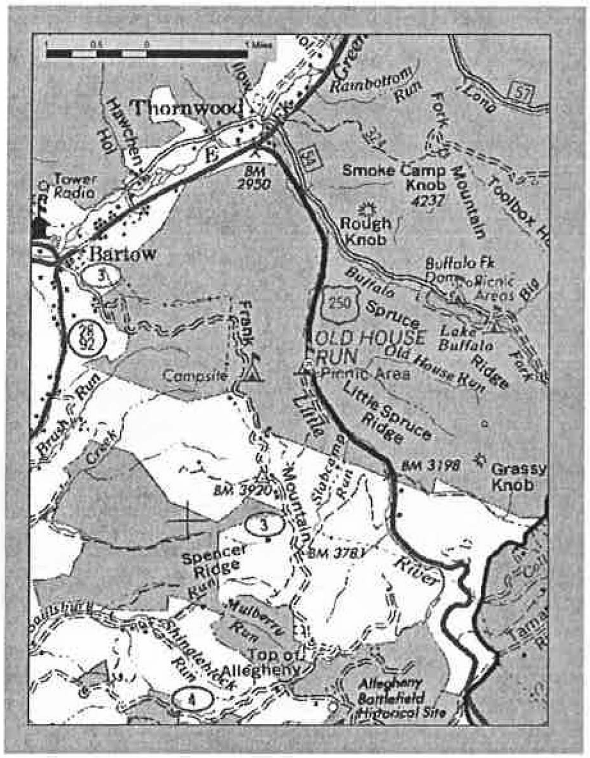
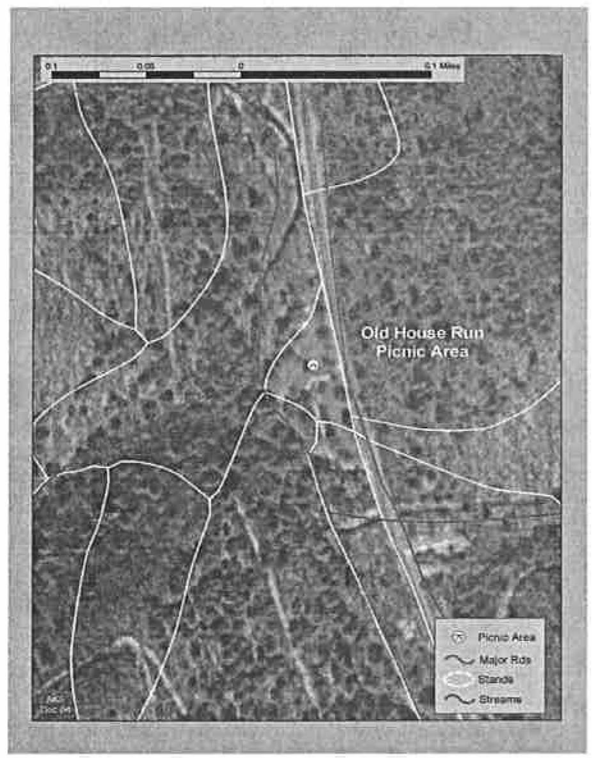
PROJECT LOCATION/DESCRIPTION

The Old House Run Picnic Area (OHRPA) is located approximately 5 miles east of Bartow, West Virginia, on U.S. Route 250 (figures 1 and 2). One of the eastern gateways to the Monongahela National Forest (MNF), this small picnic area offers travelers a beautiful place to stop as they enter West Virginia (USDA Forest Service). The OHRPA has several family sites with tables, grills, and a group picnic shelter serving groups of 25 or more. The OHRPA encompasses about 3 acres and consists of eastern hemlock, rhododendron, and mixed hardwoods.

Figures 1 and 2. ***Old House Run Picnic Area, Greenbrier Ranger District, Monongahela National Forest.***





PROJECT OBJECTIVES

The objectives of this biological evaluation were to 1) assess current hemlock woolly adelgid (HWA) population densities within eastern hemlock trees at the OHRPC, and 2) develop treatment alternatives and recommendations to reduce and/or control the hemlock woolly adelgid.

PROJECT METHODS

The methods used to evaluate current adelgid population density and impacts included[1]: 1) visual estimates of individual-tree adelgid densities (based on the percentage of new growth

[1] Because of restrictions on destructive sampling, Forest Health Protection staff members were unable to sample trees with branches above a reachable height.

infested with HWA[2]) and 2) visual estimates of tree condition. A 100 percent inventory of all hemlock trees (> 6" dbh) within the picnic area was used to provide the required information.

PROJECT RESULTS

Hemlock woolly adelgid was found throughout the OHRPA. Infestation ranged from none to heavy within the area. Current HWA populations are high enough to cause reduced growth and future mortality of infested trees.

Thirty-five hemlock trees were sampled within the ~ 3-acre Old House Run Picnic Area (comp. 99, stand 32) for the presence of hemlock woolly adelgid. Hemlock woolly adelgid was found on 80 percent of the trees examined. Most trees were 18 inches and greater in diameter and were showing signs of decline (thinning crowns, off color needles, etc.).

MANAGEMENT ALTERNATIVES

Four management options have been evaluated for the hemlock trees at the Old House Run Picnic Area. The intervention options were evaluated based upon the following objectives: 1) protecting hemlock resource values, and 2) reducing hemlock woolly adelgid populations in infested areas. Each option is discussed below.

Alternative 1: No Action

This alternative is considered the environmental baseline (the no action alternative). As a result, HWA populations would be allowed to increase and decrease naturally, without intervention. Because HWA has a high reproductive capacity and has demonstrated the ability to rapidly spread in recent years, it is expected that HWA populations would continue to increase throughout the OHRPA and accelerate their spread to currently uninfested trees and stands within this area. Population densities will likely fluctuate periodically depending on the severity of winters, but rebound following such events, and consequently, impacts to hemlock resources throughout the OHRPA would likely increase as more hemlocks succumb to this insect.

Alternative 2: Release Predator Beetles to Establish Long-Term Population Control and Use Systemic Insecticides (Recommended Action)

This alternative involves the release of laboratory reared predator beetles *Sasajiscymnus tsugae* [formerly *Pseudoscymnus tsugae*], *Laricobius nigrinus*, *Scymnus sinuanodulus*, and *Scymnus ningshanensis* in hemlock woolly adelgid-infested hemlock trees to accelerate the establishment of these predator beetles. The number of beetles released would vary by species (based on availability) but would range from several hundred to several thousand. Monitoring and evaluation efforts will continue for 3 years after release to document the establishment and dispersal of the beetles and evaluate their effectiveness in reducing HWA population densities and protecting hemlock health on a stand-level basis. USDA Forest Service Forest Health

[2] Based on visual estimates from 3-5 hemlock branches: Heavy = (>50% of new growth [NG] infested by HWA), Moderate = (50% to 25% of NG infested), Light = (<25% of NG infested), None = (0% infested), Unknown = No NG present or no branches reachable.

Protection (FHP) entomologists will be providing a work plan with protocols to be followed for the 3-year project. USDA Forest Service FHP personnel will be responsible for conducting the releases, monitoring beetle dispersal and changes in HWA population densities, conducting tree health assessments, and reporting their results.

This alternative also involves the use of trunk- and soil-injected systemic insecticides to reduce hemlock woolly adelgid populations on moderately to highly infested trees. Monitoring and evaluation efforts will continue for 3 years after treatment to document the effectiveness of treatment in reducing HWA population densities and protecting hemlock health on an individual-tree basis. USDA Forest Service Forest Health Protection entomologists will be providing a work plan with protocols to be followed for the 3-year project. Additional treatments within this site are possible in the future based on monitoring results.

Several types of systemic insecticides can be injected (e.g., imidacloprid, bidrin, or Metasystox-R®) or implanted (e.g., acephate) into hemlock trees, and another (Merit®) can be applied as a soil drench or injected into the soil around hemlock trees. These insecticides are absorbed and transported by the vascular system of the tree to feeding adelgids and will effectively suppress HWA populations (McClure 1992a, Steward and Horner 1994, Evans 2000, Doccola et al. 2003, Webb et al. 2003). Of the trunk- and soil-injection systemic insecticides available, only imidacloprid marketed under the trade names Merit®, Pointer®, Imi-jet®, or Imicide® is currently labeled for soil and tree injection for the control of adelgids in forest trees.

Alternative 3: Other HWA Control Alternatives Considered, but Dismissed

3.1 Ground spraying with horticultural oils, insecticidal soaps, and foliar insecticides

These methods of treatment can be effective in situations where there is access to the trees for ground spraying equipment, including pumping trucks with high-pressure hoses, and the entire crown of each tree can be saturated with the spray (Evans 2000). Although this type of access is available for part of the OHRPA, concerns about drift caused this alternative to be dismissed.

3.2 Aerial spraying

Aerial spraying with horticultural oils or insecticidal soaps is not an effective treatment because it fails to provide the needed "saturation" coverage of each tree crown. Aerial spraying with more toxic insecticides (e.g., malathion or diazinon) would have very significant, unacceptable impacts on a wide range of nontarget insects and other animals (Evans 2000). Therefore, this alternative was considered infeasible and was dismissed.

3.3 Pheromone traps or other methods of disrupting reproduction

Because HWA reproduces asexually (its populations are entirely parthenogenetic; females reproduce without males), it is not possible to disrupt reproduction through pheromone traps or other, similar methods (Evans 2000). Therefore, this alternative was considered infeasible and was dismissed.

RECOMMENDATIONS

It is recommended that the Monongahela National Forest decide in favor of **Alternative 2** (release and establishment of predator beetles and soil and trunk injections of the systemic insecticide imidacloprid) in the OHRPA. Soil and trunk injections of imidacloprid are expected to reduce HWA populations on moderately to heavily infested trees and provide 3 to 5 years of protection. These insecticidal injections are designed to buy hemlocks enough time to allow the introduced predator beetles to become established, reduce the impact of HWA, and provide long-term and effective control in a cost-efficient manner. Both actions are needed to establish natural control of HWA and provide hemlock protection over the long term.

Host acceptance tests and choice tests have demonstrated that predator beetles will feed on nontarget adelgid species and the possibility exists that other adelgid and aphid species may be fed on. Imidacloprid is a systemic and contact insecticide exhibiting low to moderate mammalian toxicity, with primary activity on sucking insects. With this treatment option comes the potential for nontarget effects; land managers must balance the risk of these effects with the potential benefits that come with the control of the HWA and retention of hemlock trees on this site.

ADDITIONAL INFORMATION

Hemlock Woolly Adelgid

Adelgids are small, soft-bodied insects that feed on plant sap. The family is divided into two genera: *Adelges* and *Pineus*. The members of this family feed exclusively on conifers. There are six species of *Adelges* that occur in North America, of which only one is native (Montgomery 1999)—the Cooley spruce gall adelgid (*Adelges cooleyi*). This adelgid occurs coast to coast in Northern North America. Its primary hosts are recorded as white (*Picea glauca*), blue (*Picea pungens*), Sitka (*Picea sitchensis*), and Engelmann (*Picea engelmannii*) spruce (Baker 1972). It has an alternate host, Douglas fir (*Pseudotsuga menziesii*). There are 10 species of *Pineus* that occur in North America, of which seven are native. Four of these (the pine bark adelgid (*Pineus strobi*), the pine leaf adelgid (*Pineus pinifoliae*), the red spruce adelgid (*Pineus floccus*), and the spruce gall adelgid (*Pineus similes*)) seem to be indigenous to Eastern North America (Drooz 1989, Montgomery 1999). These species attack eastern white pine (*Pinus strobus*), red spruce (*Picea rubens*), and black spruce (*Picea mariana*) but seldom cause extensive damage (Drooz 1989, Montgomery 1999). Little is known about the population dynamics, ecological role, or the predator and parasite complex associated with these native adelgids.

Native to Asia (Japan, India, Nepal, Southwestern China, and Taiwan), the hemlock woolly adelgid (*Adelges tsugae*) (HWA) is a pest of eastern hemlock (*Tsuga canadensis*) and Carolina hemlock (*T. caroliniana*) (Onken et al. 1999, USDA 2004b), both of which are considered highly susceptible to the adelgid, with no documented resistance (Bentz et al. 2002). The Carolina hemlock is found only in the southern region of the Appalachian Mountains (Onken et al. 1999). The HWA is currently established in 16 Eastern States from Georgia to Maine (USDA 2004a), and tree decline and mortality have increased at an accelerated rate since

the late 1980s. For example, in the Shenandoah National Park, hemlock crown health has declined since the early 1990s. In 1990, greater than 77 percent of the hemlocks sampled were in a "healthy" condition; by 1997, less than 10 percent were in a "healthy" condition (Akerson and Hunt 1998). New Jersey has estimated a loss of 9 percent of its hemlock resource and 44 percent remains moderately to severely impacted by HWA (Onken et al. 1999). Similar adelgid-caused impacts are also affecting all districts of the Monongahela National Forest.

The hemlock woolly adelgid is parthenogenetic (an all-female population with asexual reproduction) and has six stages of development (the egg, four nymphal instars, and the adult) and two generations a year on hemlock[3]. One generation (the sistens) is wingless, hatches in late spring and overwinters, and survives about 9 months. The other generation (the progrediens) hatches in early spring, is composed of both winged (sexuparae) and wingless offspring, and survives for about 3 months (USDA 2004b). Each adult adelgid can produce between 50 to 300 eggs in its lifetime (McClure 1989, 1995). Although natural mortality in HWA populations is commonly between 30 and 60 percent (McClure 1989, 1996), the reproduction potential of this insect remains high. This natural mortality is generally attributed to two likely causes: 1) an extended period of cold temperatures that coincides with a susceptible period of development for the adelgid, and/or 2) a sufficient loss in the nutritional quality and quantity of the food source, which is associated with the decline in health and vigor of the host tree (McClure 1996, Onken et al. 1999). Adelgid feeding can kill a mature tree in about 5 to 10 years (McClure et al. 2001, Orwig 2002). This tiny insect (~ 1 mm) feeds on all life stages of hemlock, from seedling to mature, old-growth tree. The feeding causes the needles to desiccate (dry up) and the buds to stop growing (USDA 2004b). Dispersal and movement of HWA is associated with wind, birds, deer, and other forest-dwelling mammals. Humans also move the adelgid during logging and recreational activities (McClure 1995). Natural enemies capable of maintaining low-level HWA populations are nonexistent in Eastern North America (Van Driesche et al. 1996, Wallace and Hain 1998).

HWA was first reported in the Western U.S. in the 1920s (Annand 1924, McClure 2001). HWA populations on western tree species, including western hemlock (*Tsuga heterophylla*) and mountain hemlock (*T. mertensiana*), appear to be innocuous; these tree species are believed to be resistant because little damage has been reported (McClure 2001). Unfortunately, both tree species are of limited value for hybridization and planting due to their poor adaptation to the east coast environment (Bentz et al. 2002). In the East, HWA was first reported in the 1950s near Richmond, Virginia. It was considered to be more of an urban landscape pest and was controlled using a variety of insecticides applied with ground spraying equipment. Observations of the adelgid were periodically reported in several Mid-Atlantic States in the 1960s and 1970s but it was not until the 1980s that HWA populations began to surge and spread northward to New England at an alarming rate. By the late 1980s to early 1990s, infestations of HWA were reported to be causing extensive hemlock decline and tree mortality in hemlock forests throughout the East (McClure 2001).

[3] The winged form that is produced by the **progrediens** generation must complete part of its life cycle on spruce. The apparent lack of a suitable spruce host for this form in Eastern North America results in a substantial loss of adelgids each year (McClure 1992b).

Hemlock Woolly Adelgid Predators

Sasajiscymnus tsugae

Sasajiscymnus tsugae [formerly *Pseudoscymnus tsugae*] is a tiny (~ 2 mm) coccinellid (ladybird) beetle native to Japan (Sasaji and McClure 1997). The life cycle of *S. tsugae* consists of the egg, four larval instars, the pupa, and the adult. Two overlapping generations per year are produced, and these coincide well with the two HWA generations. Adult and larval beetles feed on all life stages of the HWA (Hennessey and McClure 1995). Host suitability tests (tests that determine whether an agent can complete development and reproduce), choice feeding tests, and host acceptance tests (tests that determine whether an agent will feed or reproduce on a host) indicate that *P. tsugae* will feed on and develop on other adelgid species (McClure and Cheah 1998) along with feeding on the woolly alder aphid (*Prociphilus tesselatus*) (Butin et al. 2002).

Extensive laboratory and field tests in Connecticut have demonstrated that *P. tsugae* is an excellent natural enemy of HWA (Cheah 1998). Since 1995, over 1 million *S. tsugae* have been released in 15 Eastern States (McClure and Cheah 2002, Cheah 2004), including the Fanny Bennett Tract, Falls of Hills Creek, and Bird Run Campground on the Monongahela National Forest.

Laricobius nigrinus

Laricobius nigrinus is a tiny (< 3 mm) Derodontidae beetle native to Western North America (Zilahi-Balogh et al. 2002). The life cycle of *L. nigrinus* consists of the egg, four larval instars, the pupa, and the adult. One generation occurs per year. Adults become active in the early months of the fall and feed on HWA nymphs all winter. In late January, they begin laying eggs in the HWA wool sacs (ovisacs) and continue through June. The onset of egg laying coincides with the egg laying of the overwintering generation of HWA (Zilahi-Balogh 2004). After hatching, the larvae feed on the eggs of HWA. On completion of feeding, mature larvae drop to the ground and pupate in the soil at the base of the tree where they aestivate through the summer (Zilahi-Balogh 2004). The new generation of adults emerges from the soil in the early fall (Lamb 2003).

L. nigrinus has been found in close association with HWA on western hemlock in British Columbia, Washington, Oregon, and Idaho where HWA is not considered a forestry pest (Zilahi-Balogh et al. 2003). *L. nigrinus* was imported into Virginia from British Columbia, Canada, in 1998. Host suitability tests and host acceptance tests indicate that *L. nigrinus* will feed on other adelgid species, but can only complete development and reproduce on HWA (Zilahi-Balogh et al. 2002). Extensive laboratory and field tests in Virginia have demonstrated *L. nigrinus* to be an excellent natural enemy of HWA (Zilahi-Balogh et al. 2002). In 2003, *L. nigrinus* was released in seven Eastern States, including the Brushy Mountain area on the Monongahela National Forest.

Scymnus sinuanodulus and Scymnus ningshanensis

Scymnus sinuanodulus and *Scymnus ningshanensis* are both tiny (~ 2 mm) coccinellid (ladybird) beetles native to China (Montgomery 2001, Butin et al. 2004). The two beetles are very similar in appearance and biology. The life cycle of these beetles consists of the egg, four larval instars, the pupa, and the adult (Montgomery 2001, Lu et al. 2002). Both have only one generation per year (Montgomery 2001). The adults and beetles feed on all life stages of the HWA (Lu and Montgomery 2001, Butin et al. 2003); however, larvae (first instar) are specialists on eggs (Montgomery 2004). Host suitability tests (developmental tests), choice feeding tests, and host acceptance tests (behavioral test) indicate that both *S. ningshanensis* and *S. sinuanodulus* will feed and develop on other adelgid species (Montgomery 2001, Butin et al. 2004) along with feeding on the woolly alder aphid (*Prociphilus tesselatus*) and other aphids (Montgomery 2001, Butin et al. 2004, Montgomery 2004).

Imidacloprid

Imidacloprid is a relatively new insecticide in the family of chemicals called neonicotinoids (Felsot 2001) in the chloronicotinyl subgroup (USDA Animal and Plant Health Inspection Service 2002). It has a mode of action similar to that of the botanical product nicotine, functioning as a fast-acting insect neurotoxicant (Schroeder and Flattum 1984) that binds to the nicotinergic receptor sites in the postsynaptic membrane of the insect nerve (USDA Animal and Plant Health Inspection Service 2002), mimicking the action of acetylcholine, and thereby heightening, then blocking, the firing of the postsynaptic receptors with increasing doses (Schroeder and Flattum 1984, Felsot 2001). Because imidacloprid is slowly degraded in the insect, it causes substantial disorder within the nervous system, leading in most cases to death (Mullins 1993, Smith and Krischik 1999).

Imidacloprid is considered to have low to moderate mammalian toxicity (Mullins 1993) largely because it does not bind nerve receptors in mammals sufficiently to trigger nervous activity (Felsot 2001). The selective toxicity of imidacloprid is perhaps best illustrated by its use in flea treatments approved for cats and dogs. Advantage® is applied directly to the animal's skin; this preparation carries very little, if any, risk to the animal or to the people, including children, who may handle the animal (USDA Animal and Plant Health Inspection Service 2002). Chronic (repeated dose) toxicity studies have demonstrated that imidacloprid is neither carcinogenic nor mutagenic and demonstrates no primary reproductive toxicity (Mullins 1993). In studies of metabolic fate in rats, imidacloprid was rapidly absorbed and eliminated in the excreta (90 percent of the dose within 24 hours) with little bioaccumulation (0.5 percent of the dose after 48 hours) and no biologically significant differences occurring between sexes, dose level, and route of administration (USDA Animal and Plant Health Inspection Service 2002). Imidacloprid is an insecticide exhibiting both systemic and contact activity. The spectrum of activity primarily includes sucking insects (aphids, whiteflies, leaf and plant hoppers, thrips, plant bugs, and scales); many Coleopteran species; and selected species of Diptera and Lepidoptera. Activity has also been demonstrated for ants (Hymenoptera); termites (Isoptera); and cockroaches, grasshoppers, and crickets (Orthoptera). No activity has been demonstrated against nematodes or spider mites (Mullins 1993). In spider mites, imidacloprid has been demonstrated to cause an egg-laying enhancement (James and Price 2002). Since spider mites

can be a problem in hemlock, any imidacloprid-treated tree should be carefully monitored for increases in mite populations.

Frequently Asked Questions

Could introduced predators impact other native predators or parasites that rely on HWA as a food source?

There are no known parasites of HWA in either this country or its country of origin. There are no other arthropod species listed as endangered or threatened at the Federal or State level that utilize HWA as a food source; hence, no such species will be affected by the release of predators.

Of the native or introduced beetles found in natural hemlock habitat, none appear to be dependent on HWA and all have an alternate host preference. Beetle predators sometimes found associated with hemlock habitat include the twice stabbed lady beetle (*Chilochorus stigma*), which predates on hemlock scales; the Halloween beetle (*Harmonia axyridis*), which primarily feeds on aphids but will opportunistically feed on adelgids; *Scymnus suturalis,* a common predator of *Pineus* adelgids, that occasionally can be found feeding on HWA; and *Laricobius rubidus*, a derodontid beetle that feeds primarily on *Pineus strobi* on white pine but will also feed on HWA (Montgomery 1999). Brown lacewing, midge, and syrphid larvae have also been observed in association with HWA in Connecticut but in low numbers (Montgomery 1999); these larvae are sometimes associated with egg masses of the HWA at low densities but all are generalists and prey on mites, aphids, and other insect larvae (Cheah 1998). None of these predators, either individually or collectively, has a substantial impact on HWA populations (Montgomery and Lyons 1996).

Could any of the introduced predators become a nuisance to human habitations?

Behavioral studies indicate that *S. tsugae, L. nigrinus, S. sinuanodulus*, and *S. ningshanensis* do not aggregate in large numbers (McClure and Cheah 1998, Salom et al. 2000, Montgomery 2001, Zilahi-Balogh 2004), as was the case with another nonindigenous lady beetle, *Harmonia axyridis*, that was introduced into the U.S. for biological control of aphids. This beetle became a nuisance because its natural behavior is to overwinter in aggregations in caves, hollow trees, and other large, closed-in structures (Montgomery 2001).

Could soil or trunk injections of imidacloprid impact other nontarget organisms?

Yes. Imidacloprid is effective against a wide range of insect species. The following will be exposed to the effects of this insecticide: any sap- or foliage-feeding insect or its predators (including any introduced predator) or parasites, any soil-inhabiting invertebrates (including earthworms), any animals (including deer), and any insectivorous and sap-feedings birds[4] that feed directly on the foliage, sap, roots, or seeds of a treated hemlock tree.

[4] In studies with red-winged blackbirds and brown-headed cowbirds, it was observed that birds learned to avoid imidacloprid-treated seeds (at the projected recommend rate on the pesticide label) after experiencing transitory gastrointestinal distress (retching) and ataxia (loss of coordination). It was concluded that the risk of dietary exposure to birds via treated seeds was minimal (Avery et al. 1993).

Will trunk and soil injections of imidacloprid contaminate the soil and ground water around Old House Run and Little River?

Yes. To summarize the knowledge gathered to date concerning the fate of imidacloprid in the terrestrial environment, it becomes evident that this compound is both mobile and persistent (United States Environmental Protection Agency 1994). This contamination is limited (based on the method of application and the amount of material applied), however, because of the continuous processes of plant uptake, biotic degradation, photochemical (exposure to light) degradation, and the binding to soil and organic matter, ultimately leading to the formation of carbon dioxide and bound residuals (Krohn and Hellpointer 2002).

Water solubility and vapor pressure are two of the most important properties driving the environmental distribution of a compound. Imidacloprid has a high water solubility (510 mg/l) and very low vapor pressure (1.9×10^{-9} mm Hg), so it is unlikely to evaporate from soil or plant tissues and become an air contaminant (Felsot 2001b). On the other hand, its biodegradation rate (speed of breakdown by soil bacteria, plants, and animals) in soil has been characterized as not very rapid (persistence in soil allows for continual availability for uptake by the plant), with a half-life in the range of 27 days to a year in different soil types (United States Environmental Protection Agency 1994, Krohn and Hellpointner 2002). This persistence has raised a few concerns about ground water contamination. Subsequent studies have indicated that imidacloprid remains in the root zone and is only partially translocated into soil layers below 12 inches deep (Krohn and Hellpointer 2002), indicating the low potential for bioaccumulation in the environment (Bacey). Nevertheless, the EPA has reported that ground water monitoring turned up residuals of imidacloprid of 0.1-0.2 ppb (parts per billion) in California and Michigan, and 1.9 ppb in Long Island, New York. While such levels indicate a need to better manage how imidacloprid is used, they are hundreds to thousands of times lower than the levels the EPA said it would be concerned about (Felsot 2002b).

Though imidacloprid is not intended for use directly in water or in areas where surface water is present, the potential exists that it may move into Little Creek through soil injection. For this reason, we will be using a 50-foot buffer area around all areas of visible surface water. Imidacloprid does not persist in aqueous environments (Krohn and Hellpointer 2002), but in toxicity studies has been shown to be slightly toxic to fish and moderately toxic to aquatic invertebrates (United States Environmental Protection Agency 1994). For most of the aquatic species tested, imidacloprid falls into the EPA's category of practically nontoxic (LC_{50}—the lethal concentration to 50 percent of the tested animals—greater than 100,000 ppb) to slightly toxic (LC_{50} between 10,000 and 100,000 ppb) (Felsot 2001a). In studies where imidacloprid was exposed to light, it had a half-life of 1 hour in water (United States Environmental Protection Agency 1994). Thus, photodegradation is regarded as an important elimination process for all aqueous solutions of imidacloprid (Krohn and Hellpointer 2002).

By using trunk injection as our application method with the buffer zone area, we greatly reduce the potential for ground water contamination by creating a nearly closed treatment system. Imidacloprid taken up by the tree's transport system is expected to move upward and downward within the tree (Tattar and Tattar 1999) but remain sequestered in the tree's tissue and not be available on the surface of roots, wood, or leaves (USDA Animal and Plant Health

Inspection Service 2002). Since imidacloprid and its metabolites are sequestered in the tree's tissue, any needles or woody debris from treated trees that falls into the Little River will contain low concentration of insecticide.

Could soil or trunk injections of imidacloprid impact or damage trees?

Of the two application methods recommended, only trunk injections impact or damage trees. Trunk injections sever xylem cells, break the continuity of the water column at the area of injection, introduce air into cells, initiate a wound healing response in the tree, and can create a port of entry for decay and disease (Chaney 1986). Fortunately, hemlocks have no aggressive stem diseases and very few heart rots[5] (decay) that attack living trees. The fungi that do attack hemlock are considered weakly parthenogenic or nonparthenogenic (Hepting 1971).

[5] Heart rot is decomposition of the central stem wood of living trees. Heart rot or decay is caused by numerous species of fungi and is the most damaging of all tree diseases (Helms 1998).

LITERATURE CITED

Akerson, J. and G. Hunt. 1998. HWA status at the Shenandoah National Park. U.S. Department of Agriculture, Forest Service. Hemlock Woolly Adelgid Newsletter # 3: 10-11.

Annand, P.N. 1924. A new species of *Adelges* (Hemiptera: Phylloxeridae). Pan-Pac. Entomol. 1: 79-82.

Baker, W.L. 1972. Eastern forest insects. U.S. Department of Agriculture, Forest Service. Miscellaneous Publication No. 1175. 642 p.

Bentz, S.E., L.G.H. Riedel, M.R. Pooler, and A. Townsend. 2002. Hybridization and self-compatibility in controlled pollinations of eastern North American and Asian hemlock (*Tsuga*) species. Journal of Arboriculture 28(4): 200-205.

Butin, E., M.E. Montgomery, N. Havill, and J. Elkinton. 2002. Pre-release host range assessment for classical biological controls: Experience with predators for the hemlock woolly adelgid. In: Onken, B., R. Reardon, and J. Lashomb (eds.), Proceedings, Symposium on the hemlock woolly adelgid in Eastern North America, February 5-7, 2002, East Brunswick, NJ. N.J. Agricultural Experiment Station Rutgers: 205-213.

Butin, E.E., J.S. Elkinton, N.P. Havill, and M.E. Montgomery. 2003. Comparison of numerical response and predation effects of two coccinellid species on hemlock woolly adelgid (Homoptera: Adelgidae). Journal of Economic Entomology 96(3): 763-767.

Butin, E.E., N.P. Havill, J.S. Elkinton, and M.E. Montgomery. 2004. Feeding preference of three lady beetle predators of the hemlock woolly adelgid (Homoptera: Adelgidae). Journal of Economic Entomology 97(5): 1635-1641.

Cheah, C.C. 1998. Establishing *Pseudoscymnus tsugae* (Coleoptera: Coccinellidae) as a biological control agent for hemlock woolly adelgid. Environmental Assessment prepared by the Connecticut Agricultural Experiment Station. Unpub. Report. 6 p.

Cheah, C.C. 2004. Biological control of hemlock woolly adelgid. In: Reardon, R. and B. Onken (technical coordinators). FHTET-2004-04. U.S. Department of Agriculture, Forest Service, Forest Health Technology Enterprise Team, Morgantown, WV: 22.

Doccola, J.J., P.M. Wild, I. Ramasamy, P. Castillo, and C. Taylor. 2003. Efficacy of arborjet viper microinjections in the management of hemlock woolly adelgid. Journal of Arboriculture 29(6): 327-330.

Drooz, A.T. 1989. Insects of eastern forests. U.S. Department of Agriculture, Forest Service. Miscellaneous Publication No. 1426. 608 p.

Evans, R.A. 2000. Draft Environmental Assessment: For the Release and Establishment of *Pseudoscymnus tsugae* (Coleoptera: Coccinellidae) as a Biological Control Agent for Hemlock Woolly Adelgid (*Adelges tsugae*) at the Delaware Water Gap National Recreation Area. U.S. Department of the Interior, National Park Service, Northeastern Region. 23 p.

Felsot, A. 2001a. Admiring risk reduction: Does imidacloprid have what it takes? Agrichemical and Environmental News 186: 2-13.

Felsot, A. 2001b. Imidacloprid: Insecticide on the move. Agrichemical and Environmental News 186: 14-15.

Hennessey, R.D. and M.S. McClure. 1995. Field release of a non-indigenous lady beetle, *Pseudoscymnus* sp. (Coleoptera: Coccinellidae), for biological control of hemlock woolly adelgid, *Adelges tsugae* (Homoptera: Adelgidae). Environmental Assessment prepared by USDA, Animal and Plant Health Inspection Service, Riverdale, MD. Unpub. Report. 6 p.

James, D.G. and T.S. Price. 2002. Imidacloprid boosts TSSM egg production. Agrichemical and Environmental News 189: 1-11.

Krohn, J. and E. Hellpointer. 2002. Environmental fate of imidacloprid . Pfanzenschutz Nachrichten Bayer. Vol. 55 26 p.

Lamb, A. 2003. Interim progress report for rearing efforts of *Laricobius nigrinus* at Virginia Tech. Laboratory Insectary Section, Prepared by Virginia Tech. July 23 2003. Unpub. Report. 6 p.

Lu, W. and M.E. Montgomery. 2001. Oviposition, development and feeding of *Scymnus* (Neopullus) *sinuanodulus* (Coleoptera: Coccinellidae): A predator of *Adelges tsugae* (Homoptera: Adelgidae). Annals of the Entomological Society of America 90(1): 64-70.

Lu, W., P. Souphanya, and M.E. Montgomery. 2002. Descriptions of the immature stages of *Scymnus sinuanodulus* Yu and Yao (Coleoptera: Coccinellidae) with notes of life history. The Coleopterists' Bulletin 56(1): 127-141.

McClure, M.S. 1989. Evidence of a polymorphic life cycle in the hemlock woolly adelgid, *Adelges tsugae* (Homoptera: Adelgidae). Annals of the Entomological Society of America 82: 50-54.

McClure, M.S. 1992a. Effects of implanted and injected pesticide and fertilizers on the survival of *Adelges tsugae* (Homoptera: Adelgidae) and on the growth of *Tsuga canadensis*. Journal of Economic Entomology 85(2): 468-472.

McClure, M.S. 1992b. Hemlock woolly adelgid. American Nurseryman 175(6): 82-89.

McClure, M.S. 1995. Managing hemlock woolly adelgid in ornamental landscapes. Bulletin 925. Connecticut Agricultural Experiment Station. 7 p.

McClure, M.S. 1996. Biology of *Adelges tsugae* and its potential for spread in the Northeastern United States. In: Salom, S.M., T.C. Tigner, and R.C. Reardon (eds.), Proceedings, First hemlock woolly adelgid review, 12 October, 1995, Charlottesville, VA. FHTET-96-10. U.S. Department of Agriculture, Forest Service, Forest Health Technology Enterprise Team, Morgantown, WV: 16-25.

McClure, M.S. 2001. Biological control of hemlock woolly adelgid in the Eastern United States. FHTET-2000-08. U.S. Department of Agriculture, Forest Service, Forest Health Technology Enterprise Team, Morgantown, WV. 10 p.

McClure, M.S. and C.A.S-J. Cheah. 1998. Released Japanese ladybugs are multiplying and killing hemlock woolly adelgids. Frontiers of Plant Science 50(2): 6-8.

McClure, M.S., S.M. Salom, and K.S. Shields. 2001. Hemlock woolly adelgid. FHTET-2001-03. U.S. Department of Agriculture, Forest Service, Forest Health Technology Enterprise Team, Morgantown, WV. 14 p.

Montgomery, M.E. 1999. Woolly adelgids in the southern Appalachians: Why they are harmful and prospects for control. In: Gibson, P. and C. Parker (eds.), Proceedings of the Appalachian biological control initiative workshop. FHTET-98-14. U.S. Department of Agriculture, Forest Service, Forest Health Technology Enterprise Team, Morgantown, WV. 59 p.

Montgomery, M.E. 2001. Draft environmental assessment for experimental field evaluation of the lady beetles (Coleoptera: Coccinellidae) *Scymnus sinuanodulus* and *Scymnus ningshanensis* for biological control of the hemlock woolly adelgid. February 2001. U.S. Department of Agriculture, Forest Service, Northeastern Research Station, Hamden, CT. 21 p.

Montgomery, M.E. 2004. Biological control of hemlock woolly adelgid. Reardon, R. and B. Onken (technical coordinators). FHTET-2004-04. U.S. Department of Agriculture, Forest Service, Forest Health Technology Enterprise Team, Morgantown, WV: 22.

Mullins, J.W. 1993. Imidacloprid: A new nitroguanidien insecticide. In: Duke, S.O., J.J. Menn, and J.R. Plimmer (eds.), Pest control with enhanced environmental safety. American Chemical Society Symposium, ASC, Washington, DC: 183-189.

Onken, B., D. Souto, and R. Rhea. 1999. Environmental assessment for the release and establishment of *Pseudoscymnus tsugae* (Coleoptera: Coccinellidae) as a biological control agent for the hemlock woolly adelgid. U.S. Department of Agriculture, Forest Service, Morgantown, WV.

Orwig, B.A. 2002. Stand dynamics associated with chronic hemlock woolly adelgid infestations in southern New England. In: Onken, B., R. Reardon, and J. Lashomb (eds.), Proceedings, Symposium on the hemlock woolly adelgid In Eastern North America, February 5-7, 2002, East Brunswick, NJ. N.J. Agricultural Experiment Station Rutgers: 205-213.

Salom, S.M., L.T. Kok, and G.M.G Zilahi-Balogh. 2000. Evaluation of *Laricobius nigrinus* Fender (Coleoptera: Derodontidae): A predatory beetle for potential biological control of hemlock woolly adelgid, *Adelges tsugae* (Annand) in Eastern United States. Report submitted to petition for removal of *Laricobius nigrinu*s from quarantine, USDA, APHIS, August 9, 2000. 22 p.

Sasaji, H. and M.S. McClure. 1997. Description and distribution of *Pseudoscymnus tsugae* sp. Nov. (Coleoptera: Coccinellidae), an important predator of hemlock woolly adelgid in Japan. Annals of the Entomological Society of America 90: 563-578.

Schroeder, M.E. and R.F. Flattum. 1984. The mode of action and neurotoxic properties of the nitromethylene heterocycle insecticides. Pestic. Biochem. Physiol. 22: 148-160.

Smith, S.F. and V.A. Krischik. 1999. Effects of systemic imidacloprid on *Coleomegilla maculate* (Coleoptera: Coccinellidae). Environmental Entomology 28(6): 1189-1195.

Steward, V.B. and T.A. Horner. 1994. Control of hemlock woolly adelgid using soil injection of systemic insecticides. Journal of Arboriculture 20(5): 287-288.

United States Department of Agriculture. 2004a. HWA distribution map. http:// www.fs.fed.us/na/morgantown/fhp/hwa/maps/hwa-1-20-04.jpg.

United States Department of Agriculture. 2004b. Biological control of hemlock woolly adelgid. Reardon, R. and B. Onken (technical coordinators). FHTET-2004-04. U.S. Department of Agriculture, Forest Service, Forest Health Technology Enterprise Team, Morgantown, WV: 22.

United States Department of Agriculture. Animal and Plant Health Inspection Service. 2002. Draft. Use of imidacloprid formulations for the control and eradication of wood boring pests: Assessment of the potential for human health and environmental impacts.

United States Department of Agriculture. Forest Service. Old House Run Picnic Area. Monongahela National Forest, WV.

United States Environmental Protection Agency. 1994. Imidacloprid Pesticide Fact Sheet. U.S. Environmental Protection Agency. Washington, D.C.

Van Driesche, R.G., S. Healy, and R.C. Reardon. 1996. Biological control of arthropod pests of the northeastern and north central forests in the United States: A review and recommendations. FHTET-96-19. U.S. Department of Agriculture, Forest Service, Forest Health Technology Enterprise Team, Morgantown, WV: 10.

Wallace, M.S. and F.P. Hain. 1998. The effects of predators of the hemlock woolly adelgid in North Carolina and Virginia. U.S. Department of Agriculture, Forest Service. Hemlock Woolly Adelgid Newsletter #3: 3.

Webb, R.E., J.R. Frank, and M.J. Raupp. 2003. Eastern hemlock recovery from hemlock woolly adelgid damage following imidacloprid therapy. Journal of Arboriculture 29(5): 298-302.

Zilahi-Balogh, G.M.G. 2004. Evaluating host range of *Laricobius nigrinus* for introduction into the eastern United States for biological control of hemlock woolly adelgid. In: Van Driesche, R.G. and R. Reardon (eds.), Assessing host range for parasitoids and predators used for classical biological control: A guide to best practice. FHTET-2004-03. U.S. Department of Agriculture, Forest Service, Forest Health Technology Enterprise Team, Morgantown, WV. 243 p.

Zilahi-Balogh, G.M.G., L.T. Kok, and S.M. Salom. 2002. Host specificity of *Laricobius nigrinus* Fender (Coleoptera: Derodontidae), a potential biological control agent of the hemlock woolly adelgid, *Adelges tsugae* Annand (Homoptera: Adelgidae). Biol. Contr. 24: 192-198.

Zilahi-Balogh, G.M.G., S.M. Salom, and L.T. Kok. 2003. Development and reproduction biology of *Laricobius nigrinus*, a potential biological control agent of *Adelges tsugae*. BioControl 48: 293-306.

United States Department of Agriculture | Forest Service | Northeastern Area State & Private Forestry | 180 Canfield Street Morgantown, WV 26505-3101

File Code: 3410, 3420 (NA-05-03)
Date: January 31, 2005

Subject: Biological Evaluation of Eastern Hemlock Trees in the Old House Run Picnic Area, Greenbrier Ranger District, Monongahela National Forest, West Virginia

To: Clyde Thompson, Forest Supervisor
Monongahela National Forest

Enclosed is the biological evaluation of eastern hemlock trees in the Old House Run Picnic Area, Greenbrier Ranger District, Monongahela National Forest, conducted in August of 2004. We recommend using the soil- and trunk-injected systemic insecticide imidacloprid on hemlock trees within the picnic area and the release of predatory beetles to counter the hemlock woolly adelgid, *Adelges tsugae.*

I believe this evaluation will provide you and your staff with the information necessary to make decisions regarding this current outbreak of the hemlock woolly adelgid. If you or any of your staff have any questions or would like further information, please feel free to contact Rick Turcotte at (304) 285-1544.

Sincerely,

JOHN W. HAZEL
Field Representative

Enclosures
Cc: District Ranger, Greenbrier RD w/enclosures
Lewis Blodgett, HWA, MNF Coordinator, Gauley RD w/enclosures

RMT